Integrated Water Quality and Aquatic Communities Protocol – Mountain Lakes and Ponds

Standard Operating Procedure (SOP) #19: Data Analysis and Reporting

Draft Version 2.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP describes the general scheme for the data analysis and reporting of the Klamath Network Lakes protocol. It is separated into two sections: (1) General information on reporting and analyses for Annual Reports and Analysis and Synthesis reports; and (2) Specific guidelines for water quality and aquatic community analyses. The purpose of section one is to dictate the reporting schedule and content of the reports so that they meet protocol objectives. The purpose of section two is to ensure continuity of methods among personnel and reports to assist in standardization.

Reporting

The target audience of all reports (Annual and Analysis and Synthesis) is a broad group of interested parties, including park superintendents, resource managers, Inventory and Monitoring staff, external scientists, partners, and the public. The timelines and specific purposes of each report are detailed in Table 1.

Annual Reports

Annual reports serve as the main conduit for informing the audiences of the current years' monitoring activities. An example of an annual report is given in Appendix A of this protocol and should serve as a template for future reports. In all annual reports, an emphasis will be put on using summary statistics (measures of central tendency and dispersion) for the core parameters of the protocol. Findings of special interest to resource managers or the public will also be highlighted. Examples of this are instances of wildlife diseases or new records of non-native species. In general, the annual reports will not lend themselves to hypothesis testing; rather, hypothesis testing (on trends) will be covered in later Analysis and Synthesis reports. However, special interests or patterns observed may lend themselves to hypothesis testing. For example, it may be appropriate to test for differences in species' distributions from the west side of a park to the east side of the park. Recommendations for protocol revisions will also be suggested as necessary; however, actual protocol revisions will follow the steps outlined in SOP #20: Revising the Protocol.

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Table 1. Overview of data reporting for Klamath Network Lakes Protocol. Year refers to the year initiated (reports will be due the following year). *Analysis and Synthesis reports in 2024 and beyond do not have a "scheduled" topic. Rather, the Network staff at that time is encouraged to explore new and emerging avenues of summaries and analyses (with emphasis on park relevant material), but will always include a trend component. RIVPACS = RIVer invertebrate Prediction And Classification System.

Report type	Year(s)	Purpose	Method and References (if applicable)
Annual Report	Every sampling year	Summarize monitoring activities	
		Describe current status	Means/Variance/Horvitz-Thompson estimators (Manly 2009)
		Document changes/recommendations to monitoring protocols	
		Increase communication between I&M program and all parties	
Analysis and Synthesis	2013	Description of lake physical habitat gradients and patterns	Wetzel 2001
	2016	Description of lake chemistry gradients and patterns	Wetzel 2001
	2019	Description of lake biological gradients and patterns	Wetzel 2001
	2022	Index of Ecological Integrity (IEI)	Classification/Ecological Dose-response (Karr and Chu 1999)
	2025	Multivariate Observed/Expected (O/E) Ratios (RIVPACs type models)	Discriminant analysis/Predicative model (Knapp et al. 2005)
	2028 and every 3 years after	Trend Analyses (Select univariate & multivariate - IEI, O/E, species composition)	Time series (e.g., Mann-Kendall; progressive change) (Chatfield 2004; Phillipi et al. 1998)

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As information and tools increase with time (for example, the development of an Index of Ecological Integrity [IEI] in the fourth Analysis and Synthesis report), these new tools will be included in Annual Reports. Hence, the Annual Report for 2022 will report on the means and variance of calculated IEIs.

Analysis and Synthesis Reports

Reports 1-3

The first Analysis and Synthesis report will be prepared after the second sampling period (2010 and 2013). This initial report has been delayed so that some measurements of temporal variation in parameters can be included. The first, second, and third Analysis and Synthesis reports are focused on describing various gradients, parameters and patterns of three components of the lake ecosystems: physical, chemical, and biological. Future Analysis and Synthesis reports will focus the development and calibration of regionally specific indices (Index of Ecological Integrity; Observed/Expected ratios). The sixth will be the first analysis of trends for the lakes program. Follow-up Analysis and Synthesis reports will be conducted every 3 years (although an Annual Report will also be produced every 3 years, these will be separate products), and other topics will be decided in the future. Likely topics include items of interest to park managers or emerging new analytical techniques and tools as yet unknown.

The Project Lead is responsible for the accomplishment of the Analysis and Synthesis reports. The Project Lead should be knowledgeable in park resources and statistical analyses to ensure that meaningful reports are produced. If a Project Lead is being hired and their expected tenure will include the writing of these reports, a background in statistics and preferably these specific areas should be a prerequisite of the job. If the Project Lead does not have the required skills (for example, an interim Network staff member is overseeing the collection of data or non-aquatic ecologist has filled a general network position), it is the responsibility of the Network Coordinator to supplement the skill set of the Project Lead, either with personal assistance or the contracting of an outside resource (academic or USGS personnel).

Report 4: Index of Ecological Integrity

The fourth Analysis and Synthesis report will develop park-specific Indices of Ecological Integrity. These multimetric methods employ a variety of parameters to develop a single index of environmental quality based on departure from reference conditions that are considered unimpaired or undegraded by human influences. Integrated measures such as these, which collate information from different parameters, are a useful and powerful tool in monitoring (Karr and Chu 1999). Because aquatic ecosystem response to stresses often results in highly predictable compositional changes, these integrated indices are often highly robust measures of impacts to aquatic systems. A further advantage is that they can incorporate different, direct measures of predictable changes. For example, some of the parameters used in macroinvertebrate-based Indices of Biological Integrity (IBI) are based on the following categories: 1) taxa richness and composition; 2) tolerant versus intolerant organisms; 3) feeding and habitat requirements; and 4) population attributes. Integrating measures from all four parameter categories will result in a robust measure of integrity. For the purpose of the Network monitoring, we will develop an index that incorporates the best fit (based on the data) of parameters, but our model will select from parameter categories that included multiple taxa groups (amphibians, fish, invertebrates,

zooplankton), as well as physical and chemical parameters. By including these categories, we are going for a broad index of overall *Ecological integrity*, rather than the traditional *Biological integrity*.

One possible model for an IEI would be to select 10 parameters from a list of those available. Parameters are then ranked on a 1 to 5 scale (with 1 representing low quality/degraded conditions/etc. and 5 representing ideal conditions). The ranked scores on the 10 parameters are then summed for each site and a score between 10 and 50 is developed. This score is the IEI score and can be averaged and used in statistical analyses (e.g., US EPA 2007). The development and testing will be based on dose-response relationships of potential metrics to patterns of degradation.

Variability in the choice of parameters to include in an IEI model raises a valid criticism. Which IEI model is the best? While there is no easy answer, a simple response is that the best model is the model that accurately represents degraded versus pristine conditions. The difficulty arising from using only National Park Service sites to develop an IEI model is that *all* the sites may be on the pristine side of the gradient at this point in time. Development of an IEI will include sampling of lakes outside park boundaries to include sites that are less pristine. The need to develop a specific IEI for the project should be obvious. For example, it would be nonsensical to include one of the original IEI parameters from Karr (1981): % of individuals of the green sunfish (*Lepomis cyanellus*); when there are no *Lepomis* in Lassen Volcanic National Park.

Nevertheless, a park-specific IEI model can be developed, but selection of parameters to include in the park specific IEI should be transparent and parsimonious and outside experts should be consulted in building the model (as an Analysis and Synthesis report, it will be peer reviewed). Justification of final selection should include a validation dataset, which is withheld from the initial development and used to test the candidate set of parameters.

In sum, a lake IEI will be developed, but cannot be done *a priori* for the reasons listed above. When it is developed, the methods used to develop and the results will be attached as an appendix to this protocol and the procedure for calculating the IEIs will be updated in this SOP.

Analysis and Synthesis Report 5: Observed/Expected Scores

The fifth Analysis and Synthesis report will develop Observed/Expected Scores based on the River Invertebrate Prediction and Classification (RIVPACS) scheme for assessing aquatic biodiversity. While the observed portion of an O/E score is simply the number of collected taxa at a lake (often rarefied), the development of the E (expected) portion is a data intensive procedure. It consists of the following basic steps:

1. Classification – Using presence/absence data from reference condition sites (as unimpaired as possible), a resemblance matrix is calculated using a Bray-Curtis index of compositional similarity. A clustering analysis on the distances is performed to develop biologically similar clusters. Classes of sites are then assigned, based on these clusters.

2. Develop a predictive model – A Discriminate Function Model (DFM) based on environmental data is used to make predictions on class membership for new sites. For this purpose, environmental data unrelated to potential human impact are preferred (e.g.,

latitude, longitude, geological data, habitat size, volume, etc.). The DFM is further refined by calculating the likelihood that a site belongs to different classes (as defined in step 1). Hence, sites that are intermediate to different classes can be better refined by interpolation through weighting the probabilities of taxa detection.

3. Estimate – The final step is deriving the Expected taxa richness through the predictive model. The O/E score is then calculated.

Recent research, as of 2008, has focused on applying O/E models to lentic invertebrates and communities. For example, Knapp et al. (2005) and Johnson (2003) develop specific Expected scores for high elevation Sierra Nevada lakes and Swedish boreal lakes, respectively. Knapp et al. (2005) used 277 lakes in their study and Johnson (2003) used 345 lakes for model development. The development of a predictive model prior to sampling a minimal number of site (less than 50) may result in an imprecise model prone to miscategorizing sites (i.e., labeling a site as impaired when it is not). The methods employed by Knapp et al. (2005) should serve as the model for the development of Klamath Network O/E scores.

After the procedure for O/E score calculation has been accomplished in Analysis and Synthesis report 5, this SOP will be updated and revised to include this information.

Analysis and Synthesis Report 6: Trend Analyses

The sixth Analysis and Synthesis report will be the first analysis of trends in selected parameters. This will be performed after a total of five sampling periods, so that the sample size for a temporal effect will still be limited. Doing trends analyses before this point, although a major goal of this protocol, would be premature.

The trend report will be analyzed with a variety of parametric and non-parametric techniques, on both univariate and multi-variate parameters (Table 2). In general, in assessing change, a "weight of evidence approach" will be undertaken. For instance, if several tests (Mann-Kendall, regression, *and* multivariate) all agree that a significant change has occurred, this will be taken as strong evidence of biologically significant change, whereas a single test showing significant change (e.g., only the Mann-Kendall) will be taken as weaker evidence of biologically significant change.

This report will also explore the standardization of the trends analyses, allowing future Analysis and Synthesis reports to include repeatable trend analyses through preparation of standardized ”R” scripts, and other analyses incorporating new annual data.

We also expect that new techniques will emerge for studying trends that allow complex dynamics of species composition changes to be more clearly demonstrated. Emerging techniques will also be considered, and if applicable, applied to the trends Analysis and Synthesis report.

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Table 2. Proposed analyses for trend detection in Analysis and Synthesis Report 6. TSIs = Trophic State Indices; DOC = Dissolved Organic Carbon; ANC - Acid Neutralizing Capacity; IEI = Index of Ecological Integrity, respectively. * = note that although these parameters are "univariate," they are derived from a broader suite of multivariate information, and being tested with univariate techniques, provide a robust assessment of trend.

Univariate parameters	Analytical tests	References	Proposed Software
Lake Trophic Status - TSIs (total nitrogen, total phosphorous & Secchi depth)	Parametric and non-parametric time series analysis (Regression models and Mann-Kendall rank correlation tests).	Quinn and Keough (2002), Chatfield (2006), Zar (2009)	Systat, "R", or similar
Lake morphometry parameters - Volume, area, shoreline development			
Chemistry - Anions, cations, DOC, nutrients, ANC			
Biological* - Taxa richness, Shannon Index, Hilsenhoff Biotic Index, O/E scores, IEI, Fish condition index, Chlorophyll biomass			
Multivariate parameters			
Macroinvertebrates assemblages, Zooplankton assemblages, Lake communities	Indices of multi-variate seriation	Warwick and Clarke (1991), Philippi et al. (1998), Clarke and Warwick (2001)	Primer-E, PC-ORD, or similar

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The essential "statistical toolboxes" for these analyses are listed in Table 2. Time series analysis (i.e., trends) is a topic spanning several textbooks filled with multiple techniques and approaches, and even an elementary introduction is beyond the scope of this SOP. However, a good starting point for these analyses will be two of the most elementary forms of time series, and these should be the backbone of the trends reports. To assist in the implementation, some guidelines are presented below.

Linear Regression – Although multiple models of linear regression exist (see below), reporting and interpretation of trend will be based on (1) slope estimate and standard error of slope; and (2) significance of slope via analysis of variance (ANOVA) F tests. The slope estimate provides the effect size of the trend (if any) and the direction, positive or negative. The standard error of the slope is an estimate of the precision of the slope. The actual effect size of the slope should be evaluated by the Project Lead for biological significance. The statistical significance is provided by the ANOVA F test (Quinn and Keough 2002).

The three simple models of linear regression that should be evaluated by the Project Lead are: (1) Regression on "Survey" sites, with a single predictor variable (year) where sites are a simple random sample; (2) Multiple regression on "Index" sites, where there are two predictor variables (year and site); and (3) Multiple regression mixed model that incorporates Index and Survey sites into a single model, after repeat measurements of survey sites are made, similar to model 2. Regression using models 1 and 2 above should be used in early trend analyses as a weight of evidence approach. After survey sites are repeated and can be used in model 3, this will be the standard. Work is progressing on techniques to incorporate both "survey" and "index" sites into a single model prior to repeat sampling of "survey" sites by national level statisticians, and the Project Lead should consult recent work prior to the first Analysis and Synthesis report on trends.

Mann-Kendall Trends Analysis – This is a non-parametric test for trends based on the Kendall's Tau (τ), a rank-order correlation coefficient of concordance. For example, if in five time periods (1 – 5), the response value increases with each period, there will be 100% concordance. If only four of the five are in concordance, there would be closer to 80% concordance. Significance is tested by randomizing the time elements and developing a distribution of tau values based on random patterns (i.e., no effect of time). If the observed value is higher than 95% of the randomized values, the trend is statistically significant.

Indices of multivariate seriation – This is a multivariate correlational test similar to the Mann-Kendall Trends Analyses; however, the correlation is tested between the elements of two symmetrical matrices: one based on the ecological similarity (measured with a similarity index, such as Bray-Curtis) and one based on temporal distances between samples. A correlation coefficient is calculated by ranking the order of the elements and calculating the Kendall's Tau for concordance. Similar to the Mann-Kendall test, significance is tested by randomizing one matrix element and comparing the observed correlation coefficient to the resulting randomized distribution.

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Guidelines for Water Quality and Aquatic Community Analyses

The purpose of this section is to ensure standardization so that analyses of data from this program are comparable across years.

pH: Because pH is a logarithmic value, pH must be converted to the antilog (i.e., raw hydrogen ion concentration), averaged, then reconverted to pH. This should be done for averaging profile readings or if multiple locations were measured within a lake. See example in Table 3. However, when averaging pH among lakes, for example to calculate an average pH for all of the Lassen Volcanic National Park lakes, a standard average should be used.

Table 3. Example depth and pH readings taken in a hypothetical lake and how to average pH readings. Note that a straight average of the pH readings = 7.75; not 7.85, the correct value.

Depth	pH	Raw value[1]	Average raw value	Average pH[2]
0.5m	7.3	19952623.15		
1.0m	7.6	39810717.06	71413970.35	7.85
1.5m	8.0	100000000.0		
2.0m	8.1	125892541.2		

[1]can be calculated in MS Excel using "=POWER(10, value)", where 10 is the logbase, and "value" is the measured pH. [2]Average value reconverted using the "=LOG(value,10)" function in MS Excel where value is the averaged raw value and 10 is the baselog.

Approximate volume (~*V*): Because we only measure the maximum depth (z_m), the volume of a lake can only be *approximated* on the assumption that the lake has a cone-like bottom profile. Although this is not necessarily a valid assumption, a working measure for using volume as a co-variable can be calculated.

$$\sim V = \frac{1}{3}\,(A)(z_m)$$

Shoreline development (D_L): This is a ratio of the length of the shoreline (L) to the perimeter of a circle with an equal area. Hence, a calculated D_L near unity (1.0) would be a very circular habitat. With increasing D_L, the shoreline (and hence habitat) complexity increases. A lake with a large D_L would be a lake with many bays and coves and associated variation in shoreline habitats.

$$D_L = \frac{L}{2\sqrt{\pi A}}$$

Trophic status indicators (*TSI*): Trophic status indicators (TSIs) developed by Carlson (1977) serve as an index of lake enrichment or trophic state. They are calculated as below:

$$TSI\ (Secchi\ depth) = 60 - 14.41 \ln(SD)$$

Where *SD* = Secchi depth in meters. TSI for Secchi depth should only be calculated for lakes where a recorded Secchi depth exists (i.e., lakes where a secchi disk was visible to the lake bottom should not be recorded, and TSI should not be calculated).

$$TSI\ (Total\ phosphorus) = 4.15 + 14.421 \ln(TP)$$

Where *TP* = Total phosphorous in µg/L.

$$TSI\ (Total\ nitrogen) = \ 54.45 + 14.43 \ln(TN)$$

Where *TN* = Total nitrogen in µg/L.

$$TSI\ (Chlorophyll\ a) = 30.6 + 9.81 \ln(Chl\ \text{a})$$

Where *Chl* a = Chlorophyll *a* in µg/L.

Taxonomic Resolution

Taxonomic resolution may vary from site to site and year to year. One reason is that mature invertebrates (i.e., later instars of insect larvae) are more likely to have developed the diagnostic features necessary for identification. Another reason is that some taxa have only genus level keys (e.g., Ephemeroptera) and others better developed species keys (e.g., Coleoptera: Dytiscidae). Damaged individuals may also limit taxonomic resolution. Lastly, taxonomic expertise of the individual identifying the specimen may cause differences in resolution.

Standardization of taxonomic resolution is accomplished by requiring contract laboratories to only employ taxonomists certified by the North American Benthological Society (www.benthos.org), and by timing the collection of samples to similar times of the year. However, the varying amounts of taxonomic resolution present a problem in determining the total number of unique taxa in which to base taxa richness and Shannon index calculations. To this end, the contract laboratory provides the determination of which taxa not identified to the lowest practical level are "unique." This allows the taxonomist to identify a species to genus/species level for one specimen, and only identify a specimen of the same family to the family level. If he or she determines that the specimen keyed to family level is "unique," this indicates that the specimen is probably not represented by the individuals identified to the genus/species level and should be treated as a separate new taxon, despite the reduced resolution.

Abundances

Abundances should be calculated for a) Zooplankton (per cubic meter); b) Macroinvertebrates (per square meter); and c) Fish (catch per unit effort). Both zooplankton and macroinvertebrates, for logistical reasons, are sub-sampled. Although the sub-sampling is quantitative in nature, additional potentially compounding error is added to the sample. Hence, data interpretation and reporting for zooplankton and macroinvertebrates should focus on relative abundances. Although abundances for individual taxa can be ecologically relevant, the presentation of abundances for 100+ taxa over a long-term time series does not lend itself to easily interpretable summaries. Hence, presentation of abundance data should be at the gross level for these groups (e.g., all

macroinvertebrates per square meter). Abundance of individual taxa should only be included if there are special considerations justifying it (e.g., endangered or invasive species).

Shannon Index (*H'*)

This information index incorporates both relative abundance and taxa richness (Shannon 1949, Magurran 2004). It is calculated as:

$$H' = -\sum p_i \ln p_i$$

Where p_i = the proportion of the *i*th species (e.g., abundance of taxa *i* divided by the total abundance of the sample).

The calculation is straightforward and can easily be done in MS Excel or another spreadsheet. However, two important considerations must be made: 1) taxonomic resolution and 2) which logarithmic base to use. Taxonomy should be based on unique taxa (see above). Although examples of using different logarithmic base for the transformation exist in the literature, there is growing momentum to standardize on the natural log (ln) (Magurran 2004). **All Shannon Indices calculated for this monitoring program should use the natural log.**

Hilsenhoff Biotic Index (HBI)

This index is specific to macroinvertebrates. It is a weighted average of tolerance values derived from empirical observations of macroinvertebrate responses to pollution (Hilsenhoff 1987, 1988). It is calculated as:

$$HBI = \frac{\sum n_i \, a_i}{N}$$

Where n_i = the number of individuals for taxa i, a_i = the assigned tolerance value of taxa i, and N = the total number of individuals for a sample.

For consistency, a single source for tolerance values should be utilized. The source for this protocol is tolerance values developed by Mr. Robert Wisseman of Aquatic Biology Associates and is available at: http://www.cbr.washington.edu/salmonweb/taxon/. This source has been chosen because: 1) it was developed specifically for Pacific Northwest taxa, and 2) it includes non-insect tolerance values.

One advantage of the HBI is that tolerance values have been developed for Order, Family, and lower taxonomic levels. Hence, individuals that were only identified to Family can still be incorporated in the index, without making assumptions or collapsing taxonomic information.

Additional work has been done on adapting this method to zooplankton. However, the development of tolerance values for zooplankton is still relatively limited; either in geographic location (e.g., the Iberian Peninsula; Boix et al. 2005), or in habitat type (e.g., wetlands; Lougheed and Chow-Fraser 2002). When tolerance values for lake zooplankton in the Pacific Northwest become available, they should be integrated into the data analysis, with a corresponding revision to this SOP.

Fish Condition Index (*Kn*)

The Fish Condition Index (*Kn*) is based on a ratio of fish weight to length (LeCren 1951). It can be used to track the relative condition of different fish populations as they are encountered in the monitoring program. It is calculated as:

$$Kn = \frac{100{,}000\ W}{L^3}$$

Where W = weight of the fish in grams and L = the length of the fish in millimeters.

After calculating the *Kn* for each individual fish, an average *Kn* can be reported for each species in each habitat. Note that the "Fallacy of Averages" must be avoided (Welsh et al. 1988). The fallacy in this case is that an investigator might average the weights of fish, average the length of the fish, and then calculate an "average" *Kn*. Because *W* and *L* are not independent, the use of average *W* and *L* to calculate an index is mathematically improper. The example below demonstrates how averaging weight and length, and then calculating *Kn* on average weight and average length results in an erroneous value (Table 4).

Table 4. Example of hypothetical fish measurements that can result in erroneous averaged values.

Fish number	Weight (g)	Length (mm)	Condition index (*Kn*)	
1	200	80	39.1	
2	300	90	41.2	Actual average *Kn*: 41.1
3	100	60	46.3	
Average:	200	76.7		
		"average *Kn*" = 42.2		

Since the fish collection techniques used in these protocols may result in low numbers collected, any reporting of *Kn* should include the reporting of the sample size it is based on. See Anderson and Gutreuter (1983) for more information on *Kn*.

Water Quality Exceedances

Although this protocol is not designed to monitor for standards exceedances, reporting should include any instances of exceedances where encountered. Because the protocol sampling is a single point in time, any reports of exceedances should not constitute a call for management action. Instead it is a signal that there may be impairment and the parameter exceeded should be investigated using state standards (e.g., 4 day average of parameter X) to determine actual exceedance.

Both the state of California and the state of Oregon have promulgated water quality standards. However, many of the standards are for toxic substances (e.g., Polyaromatic Hydrocarbons) and do not overlap with monitored parameters under these protocols. Of the California standards, they have yet to develop standards for the monitored parameters. For Oregon, most standards are centered on allowable increases or decreases from natural conditions. Table 5 presents the

Oregon standards, along with National Park Service and Environmental Protection Agency standards.

Table 5. Summary of water quality standards available for testing exceedances. California currently does not have any overlapping standards with monitored parameters. All standards presented are for instantaneous readings. Drinking Water standards for the EPA are provided as comparison only, not for regulatory compliance.

	Oregon Standards	NPS Standards	EPA Freshwater	EPA Drinking Water
Acid Neutralizing Capacity[1]	> 20 mg/L	> 25 mg/L		
Chloride	< 230 mg/L		< 860 mg/L	< 250 mg/L
Chlorophyll *a*[2]	0.015 mg/L			
Dissolved Oxygen	> 6.5 mg/L	> 4 mg/L		
pH		> 6.5	< 9.0	< 8.5
Turbidity		< 50 NTU		
Total N as (NO_2 + NO_3)				< 10 mg/L

[1]Measured in $CaCO_3$; [2]standard for lakes that do not stratify. Standard for stratifying lakes is 0.01 mg/L, Oregon Chlorophyll *a* standards based on average of 3 samples over 3 consecutive months.

These standards may be updated, expanded, and revised by the respective agencies. The Project Lead should periodically (once per sampling event) check for updates. The sources used in Table 5 are:

Oregon - http://www.deq.state.or.us/WQ/standards/standards.htm (accessed on 21st January 2009).

California - http://www.epa.gov/region09/water/ctr/ (no overlapping parameters with current protocol; accessed on 21st January 2009).

EPA Standards - http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on 21st January 2009)

NPS Standards – Embedded in NPS Storet, v. 1.71.

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